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AIR POLLUTION WITH HEAVY METALS COMPOUNDS IN VINNYTSIA REGION, UKRAINE

Abstract

The dynamics of emission of heavy metals compounds into the air in Vinnytsia region (Ukraine) in 2003-2010 years is analyzed. The level of pollution for compounds of some heavy metals (Cd, Hg) has arisen, for others – has decreased (Pb, Cr) or has not changed (As, Ni). The sources of such pollution are defined according to the amount of the emissions of heavy metals compounds in different sectors of economy. In Vinnytsia region they include transport, industrial plants and municipal sector. Great quantity of transport and hazardous materials are consdered as the reasons of increasing of heavy metals emissions. Usage of more environment friendly resources (e.g. unleaded gasoline, natural gas instead of coal) is defined as the reason of reduction of heavy metals emissions.

Keywords: heavy metals, air pollution, emissions

1. Introduction

The problem of pollution with heavy metals and their compounds in Vinnytsia region is not new. Recently, however, the situation became more complicated. Generally, heavy metals emissions have not increased last years according to official statistics [2]. But due to insufficient funding of inspecting departments, the quantity of unauthorized emissions is arisen. It can potentially lead to "hidden" increasing of the pollution level. The situation is more dangerous now with heavy metals transfer to water and soil. At the same time there is little attention paid to air contamination with heavy metals and their compounds in Ukraine. But current secondary importance of this problem may cause significant environment degradation.

Majority of papers dedicated to pollution of the environment with heavy metals are focused on contamination of soil or water [1, 8, 10, 12], since these environments more often get heavy metals as a result of human activity. Comprehensive studies of the impact of heavy metals on air are less known and mostly related to a specific territory [3, 6, 7, 11, 13] or to a specific source of pollution [4, 5]. Such investigations for Vinnytsia region were not conducted. Some information about the content of these pollutants in the air of investigated area periodically appears in the annual reports of the State department of environment protection in Vinnytsia region [9].

Therefore the aims of this study are to identify the main sources of income of heavy metals compounds into the atmosphere in Vinnytsia region, to analyze the dynamics of heavy metals emissions into the atmosphere, as well as to identify and to study the possible causes of changes of pollution level in Vinnytsia region.

2. Material and methods

In this paper the following heavy metals are selected for analysis: lead, cadmium, mercury, arsenic, chromium and nickel. This choice is motivated by the fact that these metals play the most important role in the environment pollution in Vinnytsia region. The highest levels of heavy metals emissions into the air are in such municipalities as Ladyzhyn, Koziatyn, Vinnytsia, Mogyliv-Podilskyi, Zhmerynka, Khmilnyk. These municipalities are the most industrialized in the region and are characterized by high traffic flows.

Data of heavy metals emissions into the air in Vinnytsia region derived from stationary, mobile and other sources in 2003-2010 years are analyzed. These data have been extracted and calculated by authors from the database of the Head department of statistic in Vinnytsia region.

3. Results and discussion

According to Table 1 the major source of lead emissions into the atmosphere in Vinnytsia region is power production. During fuel combustion lead compounds are emitted with volatile ash.

Not so long ago another important source of lead compounds was transport. However, since 2007 its emissions have decreased. This is due to the law banning the use of tetraethyl lead in fuel. The same reason of decreasing was found in other countries some years ago [13]. Another source is construction industry, where numerous cement plants in Vinnytsia region have lead to air emissions [3]. In addition, there was growing concern of increasing the lead emissions in the residential sector during the last years. It can be associated with increasing use of varnish, paints, batteries, accumulators and their next accumulation without any processing.

Table 1. Lead compounds emissions into the air in Vinnytsia region, tons per year

Sector of economy	Year							
	2003	2004	2005	2006	2007	2008	2009	2010
Power production	1.86	3.140	1.64	2.072	2.010	1.972	1.8	
Processing and construction industries	–	–	0.025	0.008	0.054	0.038	0.044	
Railway	–	0.013	0.01	0.012	0.021	–	–	
Transport	0.85	2.811	2.563	2.812	0.033	0.251	–	
Commercial sector	–	0.005	0.03	0.003	–	0.002	0.003	
Residential sector	0.27	0.293	0.246	0.269	0.075	0.227	0.284	
Agriculture	0.02	0.029	–	0.015	–	0.003	–	
Metal production	0.01	0.007	0.001	0.001	–	–	–	
Gas and Oil industry	0.001	–	–	0.003	0.003	–	–	
Chemical industry	0.01	–	–	–	–	–	–	
Total	**3.02**	**6.3**	**4.51**	**5.2**	**2.19**	**2.49**	**2.13**	**1.99**

In general, emissions of lead compounds had reached a maximum in 2004–2006, then gradually decreased and stabilized at 2–2.5 tons per year.

Emissions of cadmium compounds started to increase dramatically in 2008. Moreover, there are few sources of this growth. First, this is due to the increasing quantity of transport during fuel combustion when there is emission of cadmium compounds. Second, there are constantly increasing emissions in the residential sector due to the intensive use of washing detergents which contain cadmium in households. In addition, in 2009 appeared the new source – the commercial sector (Table 2), where increase of emissions of cadmium compounds most likely caused by batteries use. All above mentioned things from residential and commercial sectors transfer to landfills, where they can partly emit heavy metals compounds (not only cadmium) into the air.

Table 2. Cadmium compounds emissions into the air in Vinnytsia region, tons per year

Sector of economy	Year							
	2003	2004	2005	2006	2007	2008	2009	2010
Processing and construction industries	–	–	–	–	0.006	–	–	
Transport	0.0005	0.002	0.002	0.002	–	0.01	–	
Commercial sector	–	–	–	–	–	–	0.115	
Residential sector	–	0.005	0.003	0.004		0.01	0.076	
Agriculture	–	–	–	–	–	–	0,013	
Total	**0.0005**	**0.007**	**0.005**	**0.006**	**0.006**	**0.02**	**0.204**	**–***

* Data not available

There was a stability of level of mercury compounds emissions in 2003–2009, while increase was noticed in 2010. It can be associated with the start of use of luminescent lamps in the households (there was a growth in the residential sector in 2009 yet). At the same time, emissions in the power production sector

have reduced (Table 3). The replacement of coal by natural gas as the primary fuel for heat production at thermal power plants may be the reason because slag wastes of these plants are source of emissions of mercury compounds.

Table 3. Mercury compounds emissions into the air in Vinnytsia region, tons per year

Sector of economy	Year							
	2003	2004	2005	2006	2007	2008	2009	2010
Power production	0.124	0.137	0.114	0.124	0.127	0.1	0.064	
Processing and construction industries	–	0.001	0.003	0.004	0.004	0.01	0.009	
Railway	–	0.001	0.0002	0.001	–	–	–	
Transport	–	–	–	–	0.0001	0.001	–	
Commercial sector	–	–	0.0005	–	–	–	–	
Residential sector	0.013	0.014	0.003	0.009	0.003	0.01	0.075	
Agriculture	0.001	0.001	–	0.001	–	0.03	–	
Total	**0.138**	**0.154**	**0.121**	**0.139**	**0.134**	**0.151**	**0.148**	**0.194**

One should note the stability of arsenic compounds emissions from most sources except the residential sector (Table 4). That can results from impermanent burning of arsenic-containing materials such as treated lumber which puts arsenic fumes into the air. The main polluters are energy companies (especially thermal power plant in Ladyzhyn) because arsenic and its compounds are found in solid fuels which are widely used at different plants.

Table 4. Arsenic compounds emissions into the air in Vinnytsia region, tons per year

Sector of economy	Year							
	2003	2004	2005	2006	2007	2008	2009	2010
Power production	1.612	3.276	1.97	2.643	2.388	1.987	2.069	
Processing and construction industries	–	–	0.03	0.038	0.103	0.046	0.032	
Railway	–	0.014	0.01	0.013	–	–	–	
Transport	–	–	–	–	–	0.267	–	
Commercial sector	–	0.005	0.045	0.002	0.001	0.003	0.003	
Residential sector	0.323	0.290	0.273	0.281	0.083	0.242	0.038	
Agriculture	0.001	0.032	–	0.016	–	–	–	
Aluminium production	–	–	–	–	–	–	0.051	
Total	**1.936**	**3.617**	**2.328**	**2.993**	**2.575**	**2.545**	**2.193**	**2.352**

Dynamics at Table 5 shows slight but steady reduction of emissions of chromium compounds. In some years there are enormous values. For example in 2004 total emissions of chromium compounds were 3-4 times more than in other years due to increase in the energy sector, which remains the main source of air pollution by chromium.

Table 5. Chromium compounds emissions into the air in Vinnytsia region, tons per year

Sector of economy	Year							
	2003	2004	2005	2006	2007	2008	2009	2010
Power production	1.84	6.689	0.948	1.193	1.167	0.963	1.048	
Processing and construction industries	–	0.017	0.116	0.033	0.185	0.097	0.119	
Railway	–	0.032	0.025	0.029	–	–	–	
Transport	0.003	0.011	0.01	0.011	–	0.628	–	
Commercial sector	–	0.011	0.116	0.005	0.002	0.006	0.007	
Residential sector	0.518	0.684	0.63	0.657	0.194	0.58	0.19	
Agriculture	0.022	0.085	–	0.037	–	0.004	–	
Metal production	0.019	0.013	0.042	0.182	0.214	0.032	0.03	
Chemical industry	0.017	0.002	0.003	0.002	0.002	–	–	
Other	–	–	–	–	0.051	–	–	
Total	**2.563**	**7.534**	**1.89**	**2.149**	**1.815**	**2.31**	**1.394**	**1.3**

There was also high level of chromium compounds emissions by transport in 2008 – 60 times more than in the previous years. Emissions of energy companies and transport usually contain some chromium compounds. But it is hard to explain such high levels. Emissions in the residential sector have reduced in recent years. However, this sector remains one of the major sources of chromium compounds emissions into the air (mainly use of varnish and paints). Reduction of emissions in the chemical industry during the past 3 years could be explained by stopping of the galvanic production in Vinnytsia region.

From the Table 6 one can see that emissions of nickel compounds into the atmosphere were constantly changing with peaks in 2004 and 2008. But last two years are characterized by relatively low values due to significant reduction of the emissions in agriculture (possibly due to significant reduction of the number of agricultural machinery which use accumulators that contain nickel) and in the residential sector (by reducing the use of conventional NiCd batteries and replacing them by rechargeable batteries, which have much longer service life). Although fewer emissions of nickel compounds in the residential sector are not correlated with an increase of emissions of cadmium compounds (the main source of nickel and cadmium in the residential sector is conventional nickel-cadmium battery).

Table 6. Nickel compounds emissions into the air in Vinnytsia region, tons per year

Sector of economy	Year							
	2003	2004	2005	2006	2007	2008	2009	2010
Power production	1.488	3.822	1.464	1.847	1.798	1.492	1.61	
Processing and construction industries	–	0.001	0.046	0.016	0.089	0.011	0.055	
Railway	–	0.177	–	0.159	–	–	–	
Transport	0.004	0.015	0.014	0.015	–	3.074	–	
Commercial sector	–	0.006	0.047	0.003	0.001	0.002	0.004	
Residential sector	0.279	3.744	0.344	2.044	0.108	3.072	0.006	
Agriculture	0.026	0.417	–	0.208	–	0.003	–	
Metal production	0.003	0.005	0.058	0.029	0.03	0.022	0.028	
Total	**1.8**	**8.187**	**1.973**	**4.321**	**2.026**	**7.676**	**1.703**	**1.816**

The largest supplier of nickel compounds into the air in Vinnytsia region is the energy and heat production (nickel compounds are contained in the products of fuel combustion, batteries, etc.).

4. Conclusions

In summary, we have studied that the dynamics of air pollution with heavy metals in Vinnytsia region has some negative trends and it should be more controlled by the state for saving our environment. The sources of such pollution in Vinnytsia region are transport, industrial plants and municipal sector. Among the industrial plants there are energy companies which are mostly responsible for the pollution with heavy metals. The key reasons of increasing of some heavy metals emissions are great quantity of transport and using the materials which contain heavy metals (batteries, luminescent lamps, etc.) in residential sector. The main reasons of reduction of some heavy metals emissions are banning the use of leaded gasoline and replacing the coal by natural gas in power production.

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